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Briefing Book Impact of Agricultural Activities on the Environment

President's Water Quality Advisory Board

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BRIEFING BOOK

IMPACT OF AGRICULTURAL ACTIVITIES ON THE ENVIRONMENT

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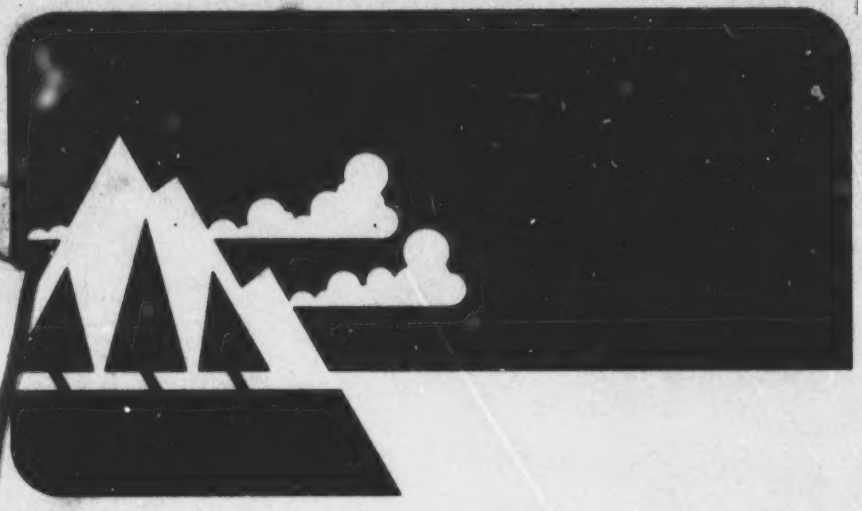

BRIEFING BOOK

IMPACT OF AGRICULTURAL ACTIVITIES ON THE ENVIRONMENT

FOR

THE PRESIDENT'S WATER QUALITY ADVISORY BOARD

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CHAPTER I

SOME WATER POLLUTION PROBLEMS ASSOCIATED WITH AGRICULTURE

The agricultural sector, like cities and industries, is now recognized as a major source of pollution. Water pollution problems directly associated with agricultural activities include: sediment from erosion, nutrients from fertilizers, pesticides, salinity and wastes from concentrated livestock feeding operations. Some of these problems are associated with both irrigated and non-irrigated agriculture.

In addition to these problems directly associated with agricultural activities, large amounts of organic waste material having a high BOD are produced in the processing of animals and plants for food, oil, and fiber. The organic waste material produced in washing fruits and vegetables, in peeling and cutting them, in cleaning dairy plant tanks and other equipment, in manufacturing corn starch and soy protein, in scouring wool, in wet processing in textile mills, in liming and tanning hides and in refining sugar constitutes a pollution load that can have a major adverse impact on water quality if it is discharged to water bodies without adequate treatment.

Some of the water pollution problems directly associated with agriculture are discussed in the following sections in terms of causes, their detrimental effects on water quality and water uses and technology for their prevention and control.

A. SEDIMENT

Sediment from erosion constitutes the greatest volume of any pollutant in the surface waters of our nation. Sediment is also a carrier of pollutants of water such as plant nutrients, insecticides, herbicides and heavy metals. Sediment is washed from croplands, unprotected forest lands, overgrazed pastures, strip mines, roads and from construction areas.

The mass of sediment loading in our streams is 500 to 700 times greater than that from domestic sewage discharge. Over four billion tons of

sediment move from land to water in an average year. In the U.S., the average annual sediment concentration for all rivers is from 200 to 50,000 ppm. Sediment concentrations for individual runoff events and small upstream watersheds are often much higher. For example, sediment concentrations up to 500,000 often occur in tributaries of the Colorado River along the Arizona-Utah border following rapid runoff from thunder storms.

About 50 percent of the sediment from erosion is attributed to agriculture, with streambank erosion being the next largest single contributor. Water erosion is a dominant problem on 179 million acres of cropland in the U.S. and a secondary problem on an additional 50 million acres. Although erosion is recognized as a normal geologic process, it has been greatly accelerated by agricultural and forestry activities, construction of roads and highways, and industrial and urban development. This accelerated erosion has increased the production of sediment far above that experienced when the country was first settled. Erosion rates of lands are increased 4 to 9 times by agricultural development, and studies have shown that sediment loads increase from 7 to 70,000 parts per million following clear-cut logging operations. Five to ten percent of silt pollution comes from forests and associated range lands. The 470,000 miles of rural and secondary roads in the United States also contribute significantly to sediment pollution.

Regardless of its origin, the movement of sediments from land to water courses is generally undesirable in every respect, although economic evaluations are uncertain at best. The useful life-span of reservoirs is closely related to the sediment load of feeder streams and sediment accumulations in navigable waterways and harbors are costly to remove. A considerable portion of flood damage results from the sediment which remains after flood waters have receded. Infertile sediments deposited on the floodplains not only damage croplands, but may also reduce the natural fertility of the eroded soil. Even moderate loads of sediment seriously impair the recreational value of rivers, lakes and reservoirs. They also add appreciably to the cost of water treatment. Bottom sediments in ponds, lakes and streams may be a source of water-soluble nutrients which may cause entrophication, as each ton of sediment carries, on an average, one pound of phosphorus. Fisheries are damaged by waterborne and deposited sediment in streams.

One expert five years ago placed the total annual damage from sediment in streams, not including loss of agricultural productivity of eroded farmland, at $262 million in the U.S. This involves a loss of $50 million from deposition on flood plains, $50 million for dredging sediment from inland navigation channels and harbors; $14 million for removing excess turbidity from public water supplies; $34 million for removing sediment from drainage ditches and irrigation canals; $31 million for miscellaneous sediment removal, cleaning and added maintenance; $2 million in other miscellaneous costs. This estimate does not include such factors as aesthetic damage or loss of recreational opportunities.

To reiterate, nearly all sediment is the result of man's removal or disturbance of natural soil cover of trees and grass. Since all land cannot be returned to its original cover, wise land use planning and treatment of land can reduce soil erosion, the source of sediment. Although the mechanics of the erosion process are not completely understood, guidelines have been developed, satisfactorily tested, and translated into erosion control practices, measures, and structures. Existing erosion control technology has not been universally accepted and used, primarily because of direct or indirect economic considerations. The challenge to agriculturists, conservationists, engineers, and economists is to continue their efforts to develop an improved erosion control technology that will be compatible with modern requirements and economically feasible. Only when this challenge is met will there be a significant reduction in sediments derived from agricultural lands.

B. NUTRIENTS FROM FERTILIZERS

Fertilizer usage in the United States has expanded rapidly in recent years. About 14 million tons of primary plant nutrients were applied to U.S. soils in 1967. This included 6 million tons of nitrogen, 4.3 million tons of phosphate and 3.6 million tons of potash. The rapid increase in fertilizer usage has been due largely to low fertilizer costs and the necessity for higher economic yields. Reliance on legumes and the use of animal manures, both for nitrogen and erosion control, have given way to chemical fertilizers in many areas. Crop varieties, with high yield potentials, have also played a major role in increased crop production. In order for these new varieties to attain their maximum yield potentials, increased fertilizer rates have been necessary. In addition to farm uses, fertilizers are being used

more on parks, playgrounds, golf courses, home lawns, roadbanks, forest recreation areas, and even in forest lands.

The rapid expansion in fertilizer use has raised many questions concerning nutrient pollution of our surface and groundwaters. Since the population of the United States is rapidly increasing, it probably will be essential that our land acres produce food and fiber at capacity levels in the future. This will necessitate the continued rise of high rates of fertilizer. However, management practices must be followed so that the high yields attained are also consistent with a clean and safe environment.

Nitrogen and phosphorus, as nutrient elements, are important to both land and aquatic plants, and normally reach water supplies via land runoff in the erosion debris which is selectively enriched in organic nutrient materials or via the leachate which may contain mobile nitrate ions. Current information suggests that phosphatic fertilizers incorporated in the soil are not contaminating natural waters, but nitrogen fertilizers may be contributory in selected situations. For example, where application rates, together with soil supplies, have exceeded crop needs and/or excessive leaching occurs induced by over-irrigation of sandy soils, nitrates can be contributed to underground water supplies.

Fertilizer phosphorus quickly converts to unavailable forms in mineral soils and the evidence indicates that one of the ways of reducing the level of soluble phosphorus in water would be to effect soil contact such as by filtration through the soil medium. Some phosphorus is removed from frozen plant materials with snow melt waters which is difficult to control except perhaps by diversion terraces into seepage areas. Nitrogen fertilizer application rates should approximate crop needs, which for a given soil type and climatic zone are based on production potential estimates for the crops to be grown. One hundred pounds of nitrogen per acre can apparently be safely applied to cropped soils without major contribution of nitrate to the leachate, and up to 300 pounds per acre in some instances, though much more research is needed in this area.

Management recommendations refined through the years for maximizing production are not incompatible with the objective of reducing nutrient contamination of natural waters. These involve an emphasis on erosion control measures to include vegetative cover

which, in addition to a reduction in runoff and erosion, removes fertilizer nutrients with the harvest and effects water transpiration to reduce leaching. Other factors include the use of cover crops where adapted and incorporation of crop residues in the fall for protection of soil surfaces and utilization of plant nutrients, minimum tillage to improve structure and reduce the mineralization of organic nitrogen reserves, and emphasis on increasing fertilizer use efficiencies by the crop, such as by split applications and the use of ammoniacal forms of nitrogen in the fall.

Further research is needed on nutrient balances and reactions in soils to maintain supplies at levels needed for crop production; to increase the efficiency of use as a percentage of that supplied, currently less than 50%; and to minimize loss of nitrate to water supplies. This would include research on nitrification-inhibiting chemicals so as to retain nitrogen in the ammoniacal form; pelleting, or other methods to reduce solubility or application of chemicals with the seed to increase uptake; and plant analysis monitoring of nutrients with needed applications applied quickly, perhaps by air or in the irrigation waters.

C. PESTICIDES

Pesticides embrace a wide variety of chemical compounds for controlling undesirable forms of life which threaten man, his possessions, and portions of the natural environment that he values. In recent years there has been a tremendous increase in the use of pesticides throughout the nation. The total value of all pesticides produced in this country was $440 million in 1964, and $12 billion in 1969. Herbicide sales rose 271 percent between 1963 and 1969. It is estimated that insecticides will almost double in use by 1975, and herbicide use will increase to more than double that of insecticides during the same period. In 1964, 470 million pounds of insecticides were used on 83 million acres of land, and 97 million acres of agricultural land were treated with herbicidal chemicals. A report in 1969 pointed to some 900 active pesticidal chemicals formulated into over 60,000 preparations in the United States. In 1968, production and sales of synthetic organic pesticides reached 1.2 billion pounds, of which about 20 percent was exported.

Slightly more than half of all pesticides produced are used in agriculture, with about 45 percent actually used on crops. Government agencies use about 5 percent; residential and industrial users account for the rest. At the current increase in usage rate, almost 15 percent a year, a billion pounds of pesticides will soon be applied annually in this country.

Pesticides can be grouped as nonpersistent, moderately persistent, persistent and permanent, based on how long they last in the environment. These lifetimes are critical in predicting and assessing ecological effects. Persistent or hard pesticides include most of the chlorinated hydrocarbons. DDT, the most widely used pesticide in the world, and aldrin, dieldrin, endrin, heptaclor, and toxaphene all belong to this group. They are not broken down easily to nontoxic compounds and have persisted in the environment for many years. For example, present information indicates that DDT can remain toxic for at least 20 years. Pesticides based on toxic, inorganic elements such as mercury, lead, and arsenic are virtually permanent. Nonpersistent chemicals have been replacing persistent ones, particularly in agriculture. The growing public concern with the use of persistent pesticides may accelerate their replacement by other types of pesticides or other control measures.

Pesticides enter water chiefly through spraying, runoff from treated areas, or waste discharge by producers. Percolation through soil to ground water and accidental dumping are minor sources. Pesticides can reach humans directly through drinking water, but the concentrations in most cases are far below toxic level. There is no evidence at present that long-term consumption of such water is harmful, but the buildup of pesticides in water may eventually prove dangerous.

Some pesticides bind tightly to soil particles; therefore, pollution by pesticides may occur from silt and soil washed off agricultural land into rivers, lakes, and coastal waters. Although a portion of the residues is released to the water, some dissolved and some suspended, an unknown amount remains with sediments after they settle. The sediments may then act as reservoirs, continually releasing residue pesticides to the overlying waters.

Initially, low levels of persistent pesticides in air, soil, and water may be concentrated at every step up the food chain. Minute aquatic organisms and scavengers, which screen water and bottom mud

having pesticide levels of a few parts per billion, can accumulate levels measured in a few parts per million -- a thousand-fold increase. Oysters, for instance, will concentrate DDT 70,000 times higher in their tissues than it is concentrated in surrounding water, but they partially cleanse themselves in water free of DDT. Fish feeding on lower organisms build up concentrations in their visceral fat which may reach several thousand parts per million and levels in their edible flesh of hundreds of parts per million. Larger animals, such as fish-eating gulls, can further concentrate the chemicals. High levels of certain pesticides have been responsible for fish kills. Marine invertebrates such as crabs, shrimps, and scallops are also susceptible to pesticides, and large mortalities have been reported. Many aquatic birds, including egrets, grebes, herons, and gulls have also died from insecticide poisoning.

Pesticides are highly important in the control of disease vectors and the production of food and fiber, as well as the nuisance insects and plants; however, they must be used wisely to avoid water pollution and other environmental problems that may seriously affect human health and welfare. A number of choices are available to reduce the dangers of pesticides in the environment. Some persistent pesticides, primarily organo-chlorine-based insecticides, can be replaced with degradable types. Nonchemical methods of pest control are also under development. Cultural control, based on selection and diversification of planting time, crop rotation, and water fertilizer management, has proven effective in many cases. In spite of substantial progress being made in the control of pesticides, much remains to be done to solve existing and emerging problems.

D. IMPACT OF IRRIGATION ON MINERAL QUALITY OF SURFACE WATERS

The nation's growing concern about all types of water pollution has raised many questions regarding the nature and extent of water quality changes associated with irrigated agriculture. As discussed earlier, water pollution problems associated with both irrigated and non-irrigated agriculture include sediment from erosion, nutrients from fertilizers, and pesticides. In addition to these problems, irrigated agriculture has a major impact on the mineral quality of surface waters. Mineral pollution, commonly known as salinity, is a problem that is becoming increasingly important in surface waters throughout the arid

portions of the West. The impact of irrigated agriculture on salinity is a complex problem which has economic, political, legal and philosophical implications, as well as physical and technological aspects.

Salinity of surface waters refers to their content of mineral salts which include mainly chlorides, sulfates, and bicarbonates of calcium, magnesium, and sodium. During the weathering of rocks and minerals, large quantities of soluble salts are formed. In humid climates these salts are generally carried out of the soil into the ground water and washed to the sea. In arid or semiarid climates, the salts may accumulate in a lower horizon of the soil or be transported to a lower drainage area where the water evaporates and the salt accumulates. Some of the soluble salts found in dry regions likely originated from secondary deposits. Parent materials high in salt were laid down usually in the bottoms of ancient lakes or seas in early geologic ages. Many shale deposits contain considerable quantities of mineral salts and these contribute to the salt in soils of local areas. In humid regions, the salt concentrations of surface waters are generally low because the soils have been leached for eons by abundant rainfall. In arid and semi-arid regions, the soils contain larger amounts of salts and the surface waters generally have higher salt concentrations.

A clear distinction exists between the two basic causes of salinity increases in streams of arid and semi-arid regions throughout the West. These may be referred to as the salt loading and salt concentrating effects. The former is associated with the discharge of additional mineral salts into the stream system by municipal and industrial wastes, by water from natural sources, and by irrigation return flows. In other words, the salt load returned to the stream from various uses is greater than that diverted, thereby increasing the salt burden in the stream. In contrast, the salt concentrating effect occurs as a result of the consumptive use of water. No additional mineral salts are discharged, and the salt load in the stream remains constant, but the salt concentration increases as a consequence of loss of water from the stream system. Irrigated agriculture often contributes to both of these types of salinity increases. Many streams in the arid and semi-arid regions of the West display a progressive increase in salinity between their headwaters and mouths, especially where a large part of the total water supply is consumptively used by irrigated agriculture.

Irrigation is generally defined as the application of water to the soil for the purpose of supplying the moisture essential for plant growth. For more than a century, irrigation has been utilized in the development of the land and water resources of the West. In the past 75 years, the total irrigated land in the western states has increased from less than four million acres to about 38 million acres, an increase of nearly 1,000 percent. During the last two decades, the value of supplemental irrigation has been recognized in the eastern United States, and nearly four million acres are now irrigated. The total irrigated land in the U.S. is projected to reach about 62 million acres by the year 2020.

Western regions account for about 95% of total water withdrawals and consumption for irrigation in the Nation. Moreover, most of the total water withdrawn in these western regions is used for irrigation. The source of irrigation water and the amounts applied per irrigated acre vary among the western regions. In the Upper Colorado Region, practically all the water comes from surface sources, while the chief source in the Texas-Gulf Region is ground water. Average withdrawals for irrigation range from less than one acre foot per irrigated acre in several eastern regions to more than five acre feet per irrigated acre in the southwest. In the Texas-Gulf Region, about 78% of the water withdrawn is consumed; but in the Columbia-North Pacific Region, only 38% is consumed. While total withdrawals for irrigation in 2020 are expected to be less than fresh-water withdrawals for self-supplied industry or for stream-electric power, irrigation will remain by far the largest consumptive use of water.

Irrigation practice involves the controlled application of water on land in order to manage the soil moisture environment to maximize agricultural production. This control extends from the diversion of water from the stream or other source of supply to the drainage of water from the soil profile. Irrigation practice, therefore, includes diversion, conveyance, measurement, application, cultivation, pump-back or reuse, runoff, and drainage. From the standpoint of irrigation return flow, the most important problems include those of water application methods, soil moisture storage, evapotranspiration, salt balance, drainage, and their interrelationships which alter the mineral quality of the return flow.

Much of the irrigation water which is applied to the crop-producing area is lost through consumptive use. As shown earlier, in some of

the arid regions of the West as much as three-fourths of the applied water is lost through the consumptive use process. Consumptive use, or evapotranspiration, is the sum of two losses: (1) transpiration, which is the water entering plant roots and used to build plant tissue and that passed through leaves of the plant into the atmosphere, and (2) evaporation, which is water evaporated from adjacent soil, water surfaces, or from the surfaces of leaves of the plant. Consumptive use can apply to water requirements of a crop, a field, a farm, a project, or an entire drainage basin.

In the evapotranspiration process the water consumed is relatively pure, and the mineral salts are left in the soil as solids or dissolved in the water not consumed. Thus, the major portion of the mass of salts in the applied irrigation water remains soluble in the soil solution. To maintain a favorable salt balance and a permanent irrigated agriculture, a more saline water must leave the land area as "return flow" either by percolating below the root zone into the groundwater or through a natural or artificial drainage system. To prevent an accumulation of salts in the soil and maintain a favorable salt balance in the root zone, an amount of water in excess of that required by the crop must be applied to the land so that the excess can pass through the soil profile and leach out the soluble salts.

The amount of water required for leaching, known as the leaching requirement, is determined by the concentration of salt in applied irrigation water and the salt concentration in the soil solution that can be tolerated by the crop. In order to maintain a favorable salt balance in the crop-producing area, the salt load removed must be at least equal to that in the applied irrigation water. If the soil contains unleashed mineral salts, the salt load removed may be greater than that in the applied water. Normally, this salt load is returned to the supply stream in a portion of the diverted water that has not been consumed. The salts are, therefore, discharged back into the stream from which they were diverted, but in a smaller quantity of water. This increased salt concentration in the stream is often detrimental to downstream water users. Each successive downstream use of water for irrigated agriculture further increases the salt concentration in the stream.

From the above discussion, it can be seen that irrigation return flows may affect both the quantity and quality of the water supply available

to all successive downstream water users. Irrigation return flow may be defined as "any water diverted for irrigation purposes that finds its way back into the supply stream or groundwater basin." The following sources may contribute to irrigation return flows: Seepage -- water seeping from canals, ditches, and other structures comprising the conveyance and distribution system; By-pass Water - water which is returned directly to the source of supply without being applied to irrigated land; Deep percolation -- applied irrigation water which finds its way to the drainage system or contributes to groundwater recharge; Tail water runoff (waste water) -- that portion of the applied water that runs off the land surface. Return flows from all of these sources may be subject to augmentation and salt pollution from numerous sources that are not connected with irrigation. Such sources include groundwater seepage; surface runoff from urban areas, highways and non-agricultural lands; and municipal and industrial waste discharges. It is difficult to identify and evaluate the nature and extent of each pollution source for such comingled waters.

In addition to these causes of salinity increases, there are other causes that may be important from a basin-wide viewpoint. These include evaporation losses from reservoirs and other water bodies, consumptive losses associated with municipal and industrial water uses, evapotranspiration losses from native vegetation on non-cropped land, and out-of-basin diversions of water.

The adverse effects of pollutants are generally discussed in terms of their impact on water uses. In the case of salinity, two general categories of water uses should be distinguished. Consumptive and non-consumptive. The former includes agricultural uses, such as irrigation and livestock watering, as well as municipal and industrial uses. The latter comprises such uses as hydroelectric power generation, navigation, water-oriented recreation, fish and wildlife habitat, silt control, and water quality control. In most regions of the West, the detrimental effects of salinity are generally confined to the consumptive uses of water. The existing levels of salinity in most streams have relatively little detrimental effect on non-consumptive, instream uses.

The detrimental effects of salinity in irrigated agriculture include: reduced crop yields if salts accumulate in soils; eventual abandonment of crop land with excessive salt accumulations; requirements

for greater volume of irrigation water for leaching of salts, and more frequent applications which increase labor costs, loss of fertilizers, and requirements for additional drainage facilities to remove leaching water.

Increases in salinity levels and associated hardness concentrations can cause damages to municipal water users in several ways. Among other effects, increased salinity may: cause water supplies to be rendered unpalatable; increase costs for water softening; increase expenditures for soap, detergents and softening additives when central softening treatment is not provided; cause accelerated fabric wear in laundering with hard water; and increase corrosion and scaling of metal water pipes and fittings.

The uses of water in industry may be classified according to purpose as cooling, boiler feed, process and general purpose. Of these four, salinity is probably most important in cooling and boiler feed water. The penalties of degraded mineral quality in cooling water use arise from two causes. First, the need to use a greater volume of makeup water in order to maintain salinity within tolerable limits in the cooling water system, and second the necessity to treat this extra volume of water in order to inhibit corrosion and scale formation. In boiler feed water, the effect of hard and saline waters are especially important for low-pressure boiler systems, the type generally employed in the manufacturing industry. The effects of a mineralized water supply, namely corrosion, scaling, foaming and caustic embrittlement of metals, must be controlled by limiting salinity levels in the boiler water system. The harder the original supply, the greater must be the volume of the blowdown and makeup water. The cost of the additional makeup water and the expense of treating it represents the economic damage of a mineralized supply in this type of industrial use.

From a westwide viewpoint, the areas most adversely affected by salinity increases from irrigation return flows are located in the lower reaches of the larger river systems of the Southwest. These include the Colorado River, which serves seven states and Mexico, the Rio Grande in New Mexico and Texas, the San Joaquin River in California, the Sevier River in Utah, and similar streams. In most instances, the water quality is excellent in the headwater tributaries of these stream systems. All of these stream systems display a progressive increase in salinity levels as the water flows to the lower reaches of the drainage basins. For example, there is approximately a twenty-fold increase

in the concentration of mineral salts in the Colorado River between its headwaters in Colorado and Imperial Dam in Arizona, the point of last major diversion in the United States.

The increasing salt concentrations in the Colorado River system have been a problem of major concern to the lower basin states and Mexico for a number of years. As a consequence, the salinity problem in the Colorado River Basin has been studied in more depth than in most of the other drainage basins of the West. The total salt load at Hoover Dam averages about 10.9 million tons per year, originating from both natural and man-made sources. Approximately two-thirds of this comes from natural sources. About 12 percent of the total load originates from point sources, such as mineral springs, abandoned oil wells and seeps. Diffuse pickup of salt occurs throughout the basin; however, the areas which contribute the greatest salt load (over 50%) are located in the upper basin. Approximately one-third of the salt burden at Hoover Dam comes from man-made sources of which irrigation is the major contributor. Municipal and industrial sources are of minor importance in terms of total load. The annual salt pickup from all irrigation above Hoover Dam averages about two tons per acre. For some areas, especially those underlain by shales and saline lake-bed formations, salt pickup is much higher with average loads ranging from four to eight tons per acre per year. In most irrigated areas along the lower Colorado River below Hoover Dam, the average annual salt load pickup is about 0.5 ton per acre, after the initial leaching period.

The concentration of mineral salts at Hoover Dam averages about 700 mg/year. Natural sources of salt are responsible for almost half of this concentration. Salt from irrigation is responsible for a little less than one-fourth of the total, while the consumptive loss of water in irrigation is responsible for about 12 percent of the total concentration effect. The only other significant factor is the loss of water due to evaporation and phireatophytes, which is responsible for about 13 percent of the total concentration effect. In the past, salt loading was the dominant factor affecting salinity concentrations in the lower Colorado River basin. Future increases in salinity levels will be the result of flow depletions by consumptive use of water, due primarily to irrigation and evaporation losses. Projections for Hoover Dam indicate a relatively constant average salt load over the next 40 years, but a substantial reduction in water flow. It is estimated that about

80 percent of the future increase in salinity concentrations at Hoover Dam will be the result of flow depletion due to the consumptive loss of water from the stream system.

Based upon present knowledge, the technical possibilities for minimizing and controlling salinity in the Colorado River Basin may be divided into two categories: water-phase and salt-phase control measures. The former comprise possibilities for reducing salinity concentrations by augmenting the water supply, while the latter embrace propsects for reducing salinity concentrations by reducing salt input into the river system. Some specific measures which may have technical merit in each of these categories are shown in the following tabulation.

I. Measures for Increasing Water Supply

A. Water Conservation Measures

1. Increased Watershed Runoff
2. Suppression of Evaporation
3. Phreatophyte Control
4. Optimized Water Utilization for Irrigation
   a. Reduced Consumptive Use
   b. Improved Irrigation Efficiency
5. Water Reuse

B. Water Augmentation Measures

1. Weather Modification
2. Water Importation
   a. Fresh Water Sources
   b. Demineralized Sea Water

II. Measures for Reducing Salt Loading

A. Control of Natural Sources

1. Natural Discrete Sources
   a. Evaporation of Discharge
   b. Injection into Deep Geological Formations
   c. Desalination
   d. Suppression of Discharge
   e. Reduction of Recharge

B. Control of Man-Made Sources

1. Municipal and Industrial Sources
   a. Evaporation
   b. Injection into Deep Geological Formations
   c. Desalination
2. Irrigation Return Flows
   a. Proper Land Selection
   b. Canal Lining
   c. Improved Irrigation Efficiency
   d. Proper Drainage
   e. Treatment or Disposal of Return Flows

Various factors, including economic feasibility, lack of research, and legal and institutional constraints, limit the present application of some of these technical possibilities for minimizing and controlling salinity. Augmentation of the basin water supply could be achieved by importation of water from other basins, by importation of demineralized sea water, and by increasing precipitation and runoff within the basin utilizing weather modification techniques. The most practical means of reducing salt loads include impoundment and evaporation of point source discharges, diversion of runoff and streams around areas of salt pickup, improvement of irrigation and drainage practices, improvement of irrigation conveyance facilities, desalination of saline discharges from natural and man-made sources, and desalination of water supplies at points of use. Some of these measures could be implemented in a variety of locations and combinations to achieve basinwide management and control of salinity in the Colorado River Basin. It is believed that some of these measures may also be utilized in the prevention and control of salinity in other drainage basins of the West.

CHAPTER II

IMPACT OF CONCENTRATED FEEDING PRACTICES ON WATER QUALITY

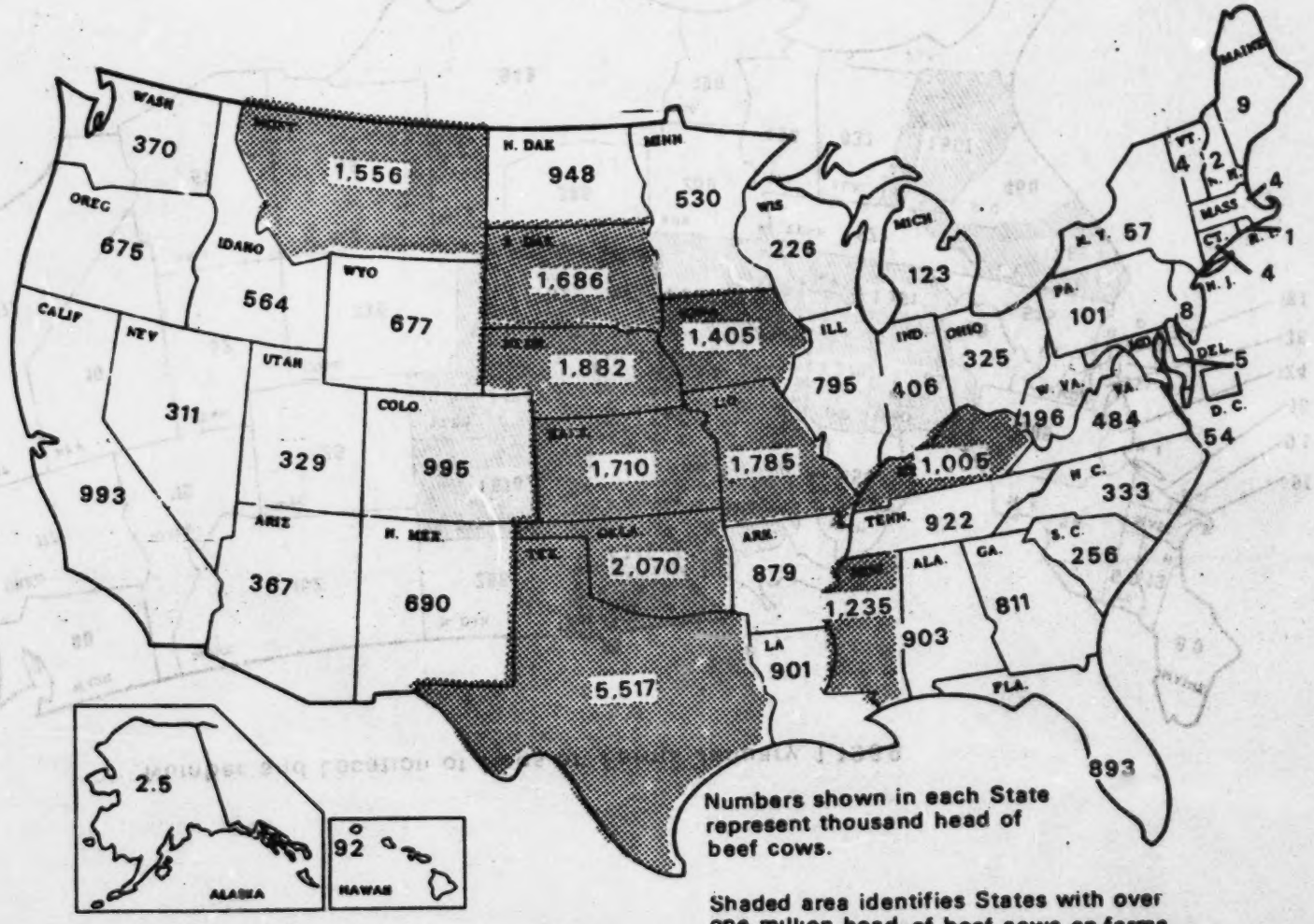
Both the increasing number of animals raised and the modern concentrated feeding methods has contributed to the increased potential pollution of waters from animal wastes. Beef cattle, poultry and swine feeding operations, along with dairy farms, are the major sources of actual or potential water pollution from animal wastes.

The magnitude of the livestock pollution problem is primarily dependent upon the number of animals that are needed to meet the demand for their products. The average population increase in the United States is about 2.5 million people per year. At 1966 consumption rates, each additional million people will require another 172,000 beef cattle, 24,500 dairy cattle and 433,000 hogs. Thus, it can be seen that if these consumption rates continue, the amount of animal wastes will continue to increase significantly. In addition, the trend toward increased use of confined feeding and concentrated rations will continue to add to the pollution potential of the animal wastes.

Agricultural waste sources are scattered across the country, with large amounts of cattle being produced in the Midwest, West and Southeast; poultry in the South and some of the Middle Atlantic States; and hogs in the Midwest and South. Although there have been few detailed assessments of the distribution of agricultural waste problems, feedlot pollution appears to be a particularly severe water pollution problem in certain parts of the States where large cattle feedlots are located. The six accompanying maps show the location and relative magnitude of the potential pollution problems from animal wastes.

Of the various types of feeding operations, it is cattle feedlots which are the major concern in the Rocky Mountain-Prairie Region. To meet the ever-increasing demand for high quality beef, the feedlot has been utilized as a means of producing a high grade carcass in a relative short time. Nearly all grain fed cattle spend the last three to five months of their 1-1/2 to 2 years of life in feedlot confinement. Cattle received in feedlots usually range in weight from 400 to 800 pounds per head. During the time cattle are in the feedlot, each animal is expected to gain about 2-1/2 pounds per day. Therefore, over the 120 to 150-day feeding period, the animals leave the feedlot weighing from 750 to 1,200 pounds each. Indications are that the feeding period and the weight of animals leaving the feedlot are increasing. A feedlot with a capacity of 5,000 head covers approximately

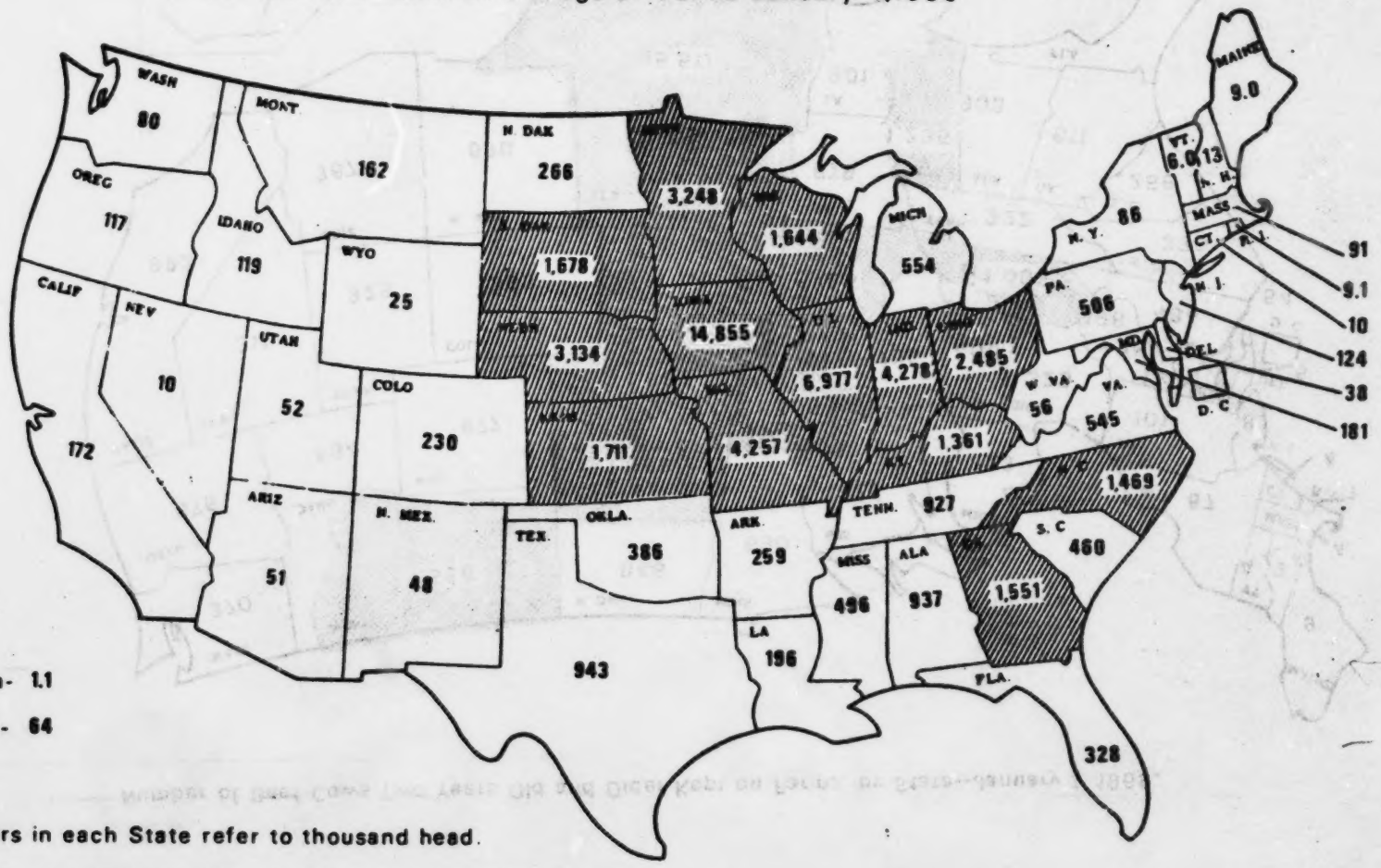
Number of Beef Cows Two Years Old and Older Kept on Farms, by State--January 1, 1969.



Numbers shown in each State represent thousand head of beef cows.

Shaded area identifies States with over one million head of beef cows on farms.

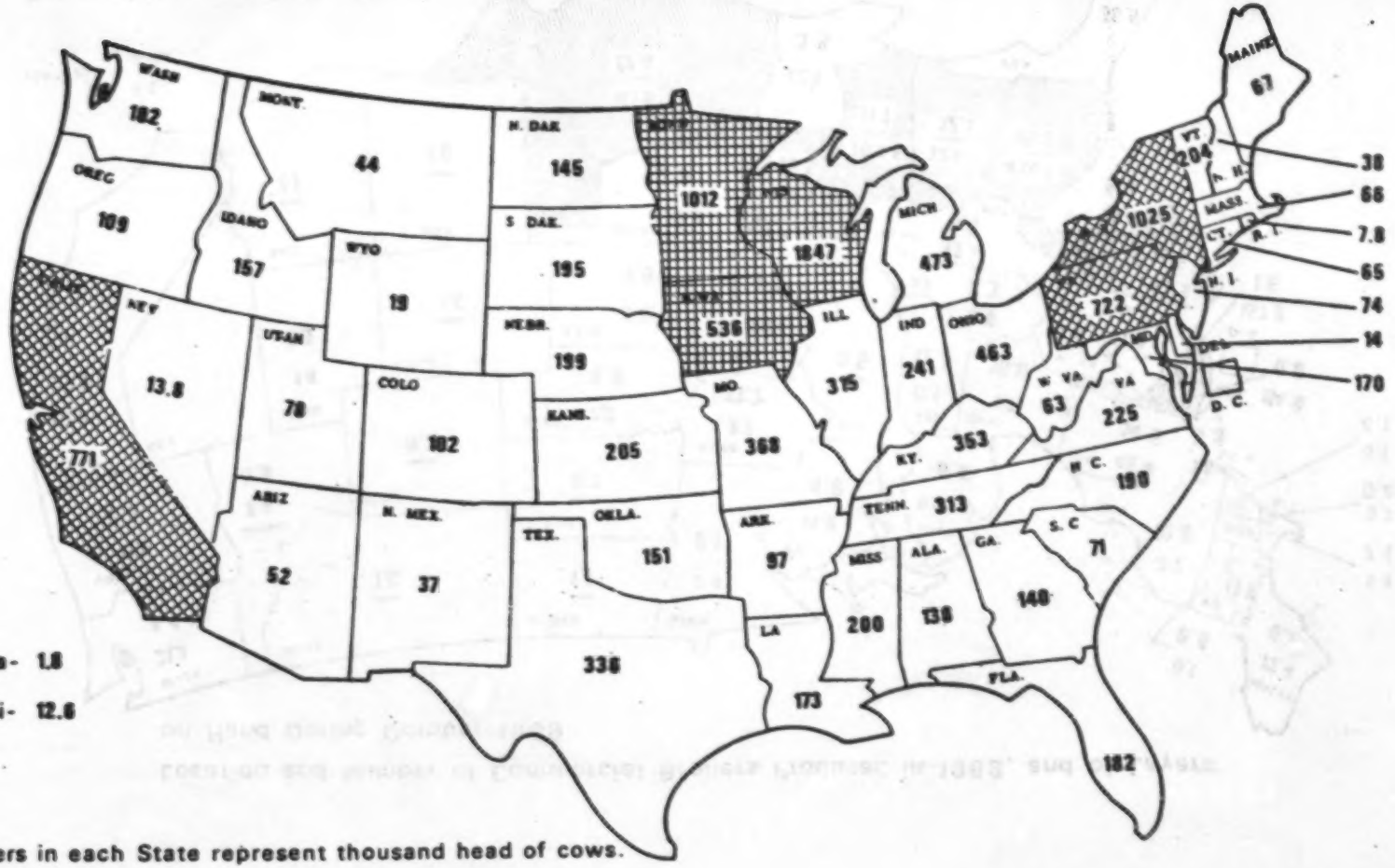
Number and Location of Hogs on Farms January 1,1969



Numbers in each State refer to thousand head.

Shaded area indicates States with over one million head.

Number of Milk Cows on Farms, by States, June 1969.



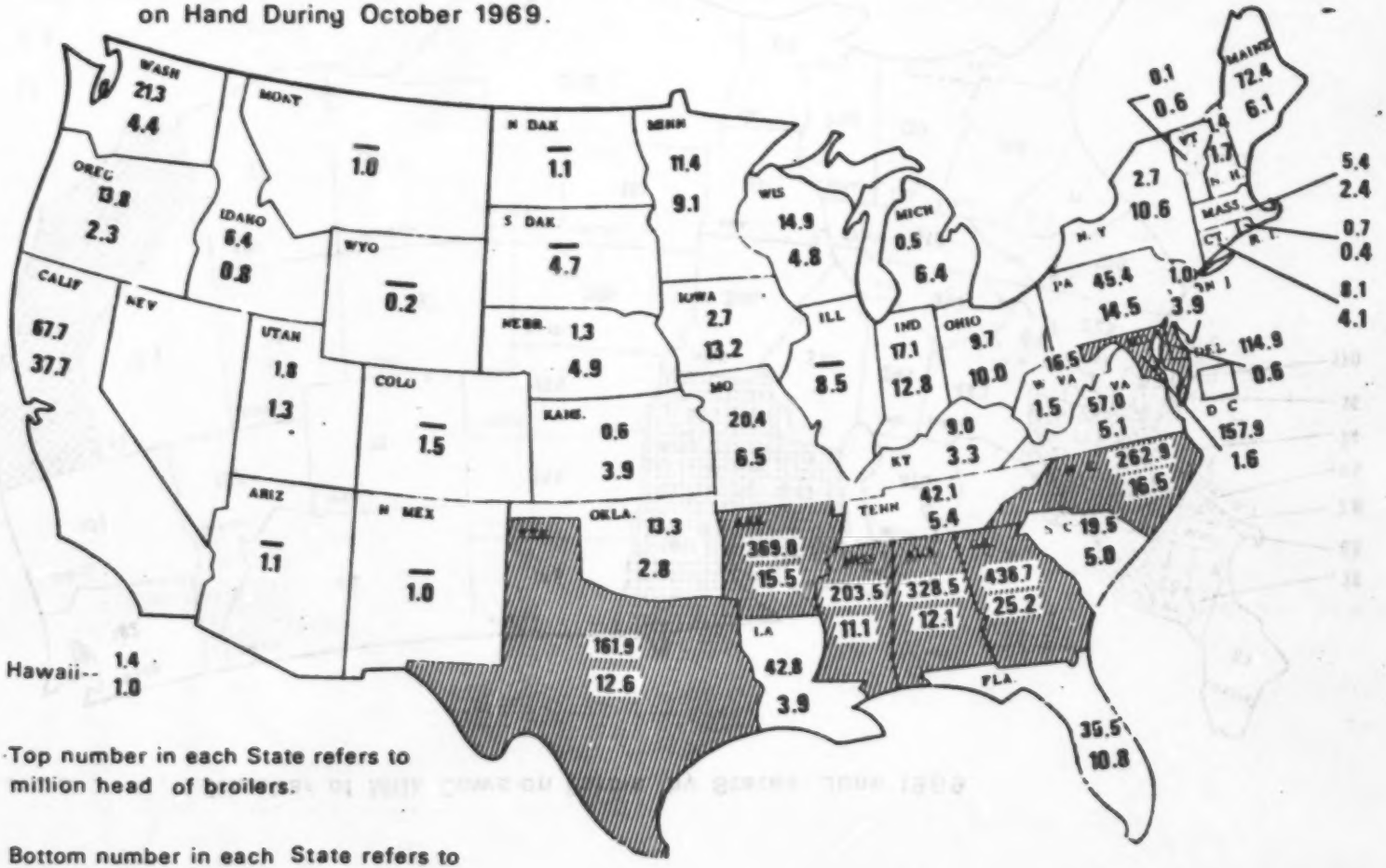
Alaska- 1.8

Hawaii- 12.8

Numbers in each State represent thousand head of cows.

Shaded areas indicate States with over 500 thousand head.

Location and Number of Commercial Broilers Produced in 1968, and of Layers on Hand During October 1969.

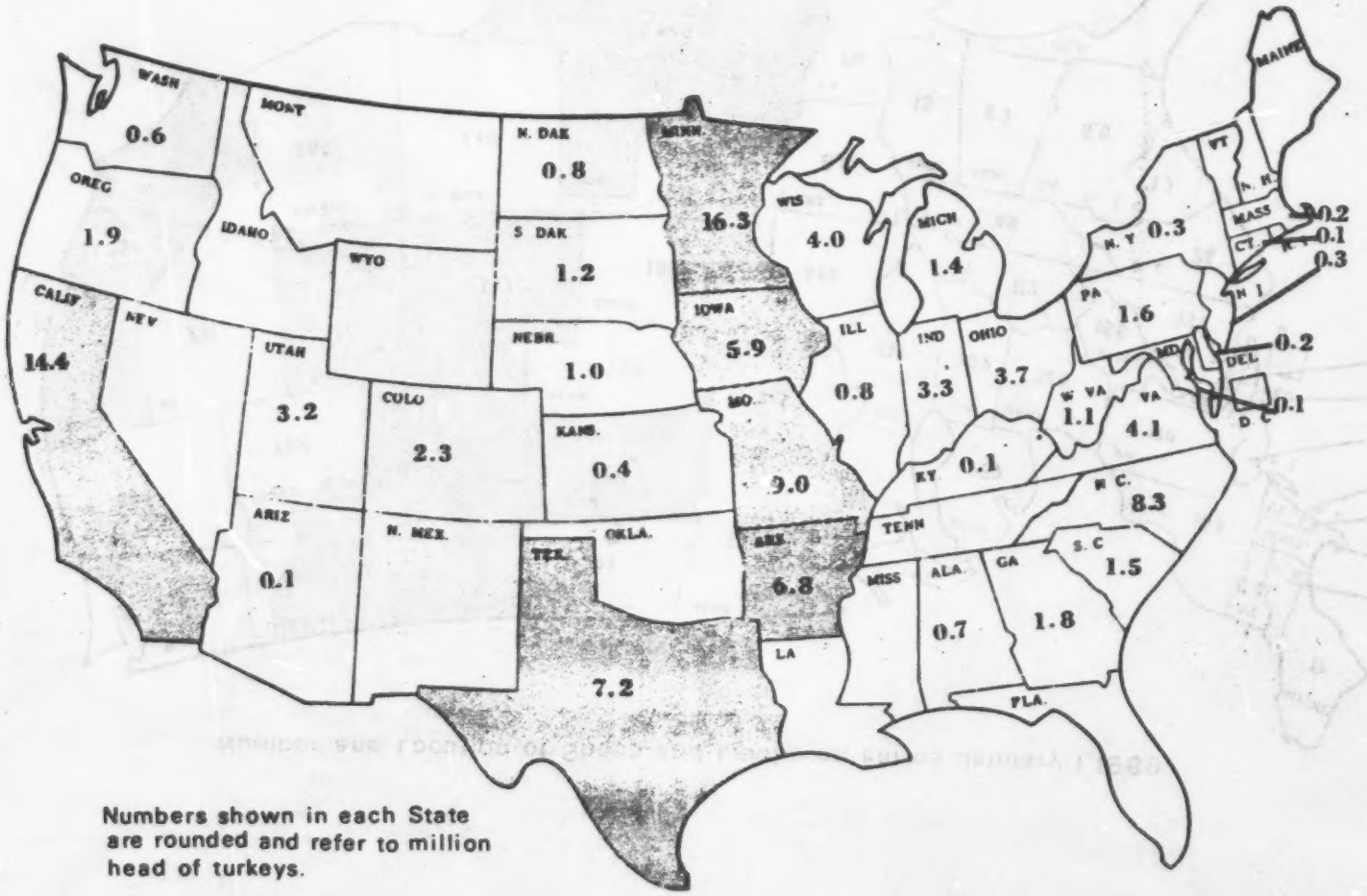


Top number in each State refers to million head of broilers.

Bottom number in each State refers to million head of layers.

Indicates States producing over 100 million broilers in 1968

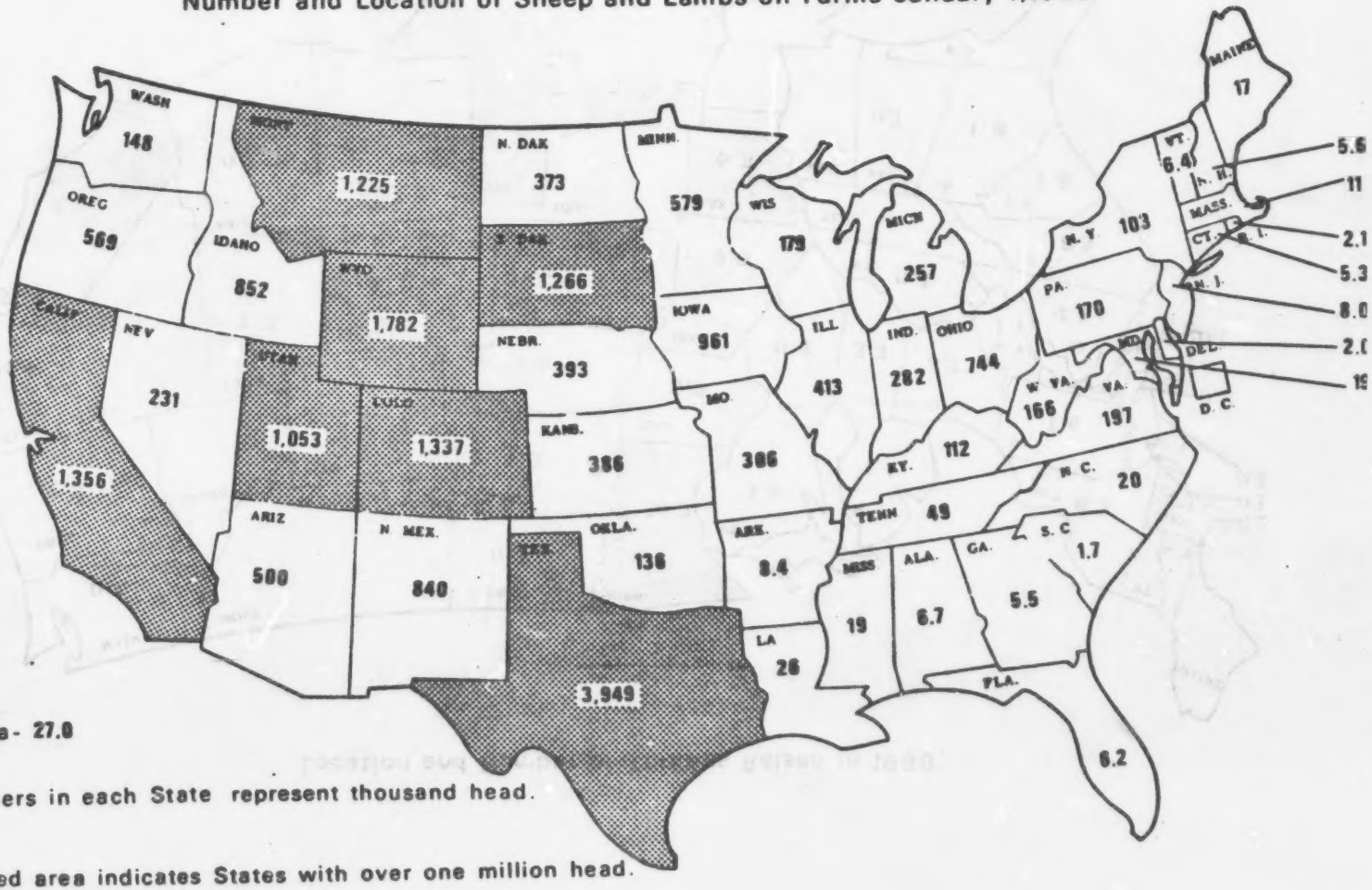
Location and Number of Turkeys Raised in 1968.



Numbers shown in each State are rounded and refer to million head of turkeys.

Shaded areas indicate States producing over five million birds in 1968.

Number and Location of Sheep and Lambs on Farms January 1,1969



Alaska- 27.0

Numbers in each State represent thousand head.

Shaded area indicates States with over one million head.

35 acres, an average of about 300 square feet per animal. Each day cattle consume about 3% of their body weight in total feeds. About two-thirds of this quantity is grain and protein. The other one-third is roughage. A 1,000-pound animal consumes about 20 pounds of grain and protein and about 10 pounds of roughage per day. Animals confined in feedlots normally consume between 10 and 20 gallons of water daily. Animals so fed produce an average of about 64 pounds of wet manure per day; and the nutritionally balanced feed results in a body waste having greater water pollution potential than is found with grassland grazed cattle.

Cattle feedlots are seldom cleaned more than two to three times per year; usually manure is removed only once per year. Periodically, however, manure on the floor of each feeding pen is mounded in a central location in the pen. This mounding allows the animals a clean area in which to stand. Occasionally, cattle feedlots have a concrete surface pen, where experimental work has shown animals gain one-third pound per head more daily than those in muddy pens. To minimize the mud problem, lots are normally constructed on land having at least 2% slope, preferably underlaid with sand or gravel.

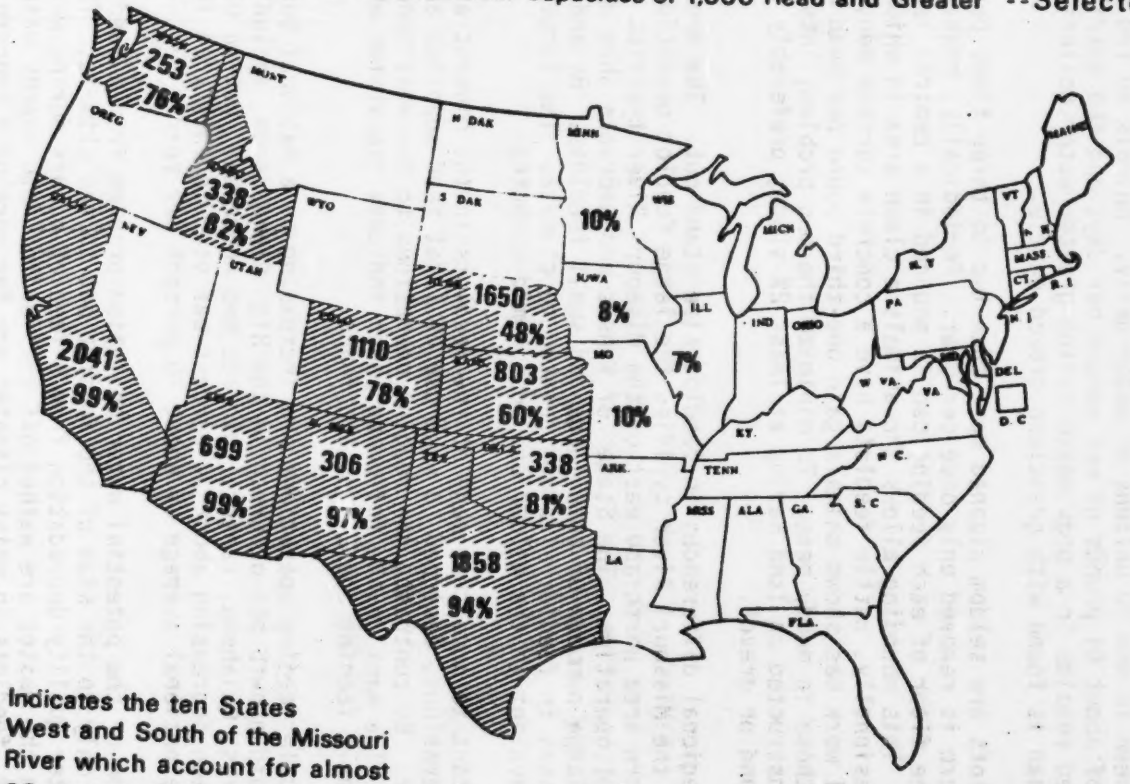
Two major regional differences in feedlot size stand out. The area south and west of the Missouri River typifies the large feedlot operation, while the Midwestern area north and east of the Missouri River typifies the small feedlot operation. The States of Kansas and Nebraska show a mixed group with large numbers of both large and small feedlots. By and large, the differences in feedlot size are related to climate. The larger lots are more prevalent in the milder and less humid climates.

It is important to note that many of the feedlots in the Midwest are seasonal operations, designed to make use of local feed supplies and off-season labor. By contrast, the feeding operations to the west tend to be year round. The maps on the following pages indicate the states where large and small feeding operations are found.

Although cattle feeding operations are increasing on a national basis, the most rapid growth has occurred in the High Plains area, including parts of Texas, Oklahoma, Kansas, Colorado and Nebraska. Cattle on feedlots have been increasing about 30 percent per year in this area in contrast to the national average of about 10 percent per year.

The magnitude of the potential water pollution problem from a feedlot is related not only to the size of the feedlot but to the climate. The most apparent water quality degradation from a feedlot occurs during wet weather when the wastes are washed off the feedlot into nearby waterways. Consequently, feedlots in moist climates are far more of a concern in terms of water quality than are those located in drier, more arid areas. Temperature is also a consideration. Surface flushing of the land can be virtually complete when there is high runoff over frozen soil. Cold weather alters the decomposition rates of organic wastes and the rates

Number and Percentage of Cattle Marketed from Feedlots with Capacities of 1,000 Head and Greater --Selected States, 1968



Indicates the ten States West and South of the Missouri River which account for almost 90 percent of all cattle marketed from lots with capacities of 1,000 head and greater.

Top number shown in each State refers to thousand head of cattle marketed from lots with capacities of 1,000 head and greater.

Percentages shown refer to the percent of cattle marketed from feedlots with capacities of 1,000 head and greater.

Due to circumstances beyond our control pages 25 and 26 are missing from this report.

In general, prevention of water pollution from cattle feeding operations requires containment of the liquid wastes and runoff and proper disposal of these and the solid wastes. The most common methods of achieving such containment of the wastes include: diversion of drainages around the feedlot; covering the feedlot; detention ponds and lagoons for the liquids and runoff; treatment of the liquids; and land disposal. These control methods, depending upon the particular circumstance, may be used alone or in combination with one another. Water diversion, for example, may be used in conjunction with most of the other methods to enhance their effectiveness or decrease their costs.

Covered feeding operations can provide a means of water pollution abatement for all sizes of feedlots in harsh and humid climates. Fully covered operations are most practical when slotted floors and pit storage for the wastes are provided. Although addition of these two items significantly raises the capital costs, they do allow the system to take full advantage of labor savings, wastes quality control, and saving in land, fencing, buildings, lot surfacing and associated costs. For example, with a covered system, each animal requires slightly more than 20 square feet of lot or floor space. When compared to the 100 to 150 square feet needed on hard surfaced open lots and the over 200 square feet required for dirt surfaced lots, it is evident that land and associated confinement costs, such as fencing, are substantially lower for the covered system. There is also evidence indicating that feeding efficiency is improved during the winter when animals are provided with simple shelter similar to that of a covered feeding system. Disease problems and death losses can also be reduced with the covered system because of lowered stress on the animals and increased herd management.

Treatment systems using lagoons for the oxidation of animal wastes have been tried on many feedlots. Success has not been complete. These lagoons are plagued by problems such as overloading, floating litter, intermittent loading, aquatic weeds, and sludge buildup. When a lagoon becomes overloaded, bacteriological decomposition changes from that caused by oxygen-using bacteria (aerobic) to that caused by bacteria which operate in the absence of oxygen (anaerobic). During anaerobic decomposition, noxious gases and odors are produced, and, under such conditions, the lagoon becomes even more malodorous than the ordinary manure pile. In addition, there is no economically feasible lagoon system known of that treats these wastes to the point where they can be discharged directly to water courses. Lagoons may, however, be used to reduce the land area needed for disposal if the salts and nitrates can be reduced by lagooning.

Routing water away from feedlot surface or away from a watercourse, where applicable, is probably the easiest and least-cost method of controlling water pollution from feedlots. In its simplest form, diversion can be accomplished by diking or channeling on the high end of the feedlot and along the sides so that water from other surface areas is channeled around the lot.

Changes in lot location can also be a method of water pollution control or a cost minimization technique when used in combination with other control measures. Locating the lot well away from watercourses or drainage channels can prevent water pollution stemming from the feedlot surface. In other cases the lot may be relocated to minimize the encroachment of surface water from other land areas around the feedlot. Reduction in outside runoff water reduces the need for, or the size of, other control measures such as diversion structures or detention ponds and lagoons.

Runoff water detention is another method for complete control of water pollution from the feedlot if the detention ponds are sized properly to handle maximum rainfalls and accumulations during extended rainfall periods when the ponds cannot be emptied. In broad terms, a runoff detention system must incorporate water channelization measures in the feedlot layout, have an adequate holding pond or area, and have an acceptable method of removing some or all of the runoff from the detention pond between rainfalls. The size or capacity of the detention pond is dependent upon the climate, lot size, and type of evacuation system employed.

Most evacuation systems fall into the evaporation class or the mechanical pumping system class. Because of the water surface area required for evaporation, these systems are only practical in areas where the evaporation rate is relatively high compared to the precipitation rate. The primary advantages of an evaporation system are minimal operation costs and limited management requirements. If the evaporation pond has been adequately designed, natural evaporative processes remove the runoff water from the pond. Therefore, there is no operating cost and no need for management of the runoff removal associated with a mechanical pump-out system. Major disadvantages of an evaporation system, even in a suitable climate, are the land requirements and complete dependence upon natural processes to remove collected runoff water.

Mechanical evacuation is accomplished by means of a pump removing water from the detention pond and forcing it through piping to a disposal area. If the disposal area is crop land, the liquids must be sprayed in quantities that add to the fertility of the soil but do not exceed the crop's requirements, impair crop growth, or adversely affect soil structure. Recent evidence from Kansas indicates that salt buildup in the soil may be one limiting factor. The chief disadvantage of such disposal is the large land requirement which results in greater costs for piping and pumping. Under certain cases, nonproductive land can be used as an evaporation area for the disposal of these liquids. The land used as an evaporation area must have certain characteristics: there should be no problem with surface runoff from the disposal area; the soils and groundwaters should be studied to assure that no pollution occurs through percolation of the wastes through the soil into groundwater; odors, nuisances, and similar problems associated with the disposal site should be within acceptable limits. The playa lakes in Texas may be ideally suited for this purpose.

Much of the current EPA research on feedlot pollution control is concerned with definition of the potential groundwater problems, loading rates on land for liquid and solid wastes, and development of better pumping systems. Recently a design manual has been developed. We are in the process of reviewing it, and when it is completed, in the spring of 1972, it should be of considerable assistance to feedlot owners attempting to solve their water pollution problems.

Waste management research is not, however, confined strictly to the animal feeding industry as it currently exists. A portion of the EPA research effort is directed toward processes that may not appear economically feasible under present operating conditions.

For example, recycling or reuse of wastes has long been of interest to the feeder and the researcher. Refeeding of cattle feedlot wastes has received considerable attention in the last several years and offers promise as a method of pollution control. A significant portion of cattle manure is undigested feed and can be recovered and fed to cattle or other animals. Although most of the work done on refeeding to date has been on the pilot scale, the preliminary results indicate that feed made from cattle manures is high in nutritive value and acceptable. But the economics and long term results of such recycling in cattle has not been demonstrated on any large scale basis, and at this point in time, FDA has not given such schemes their approval.

CHAPTER III

NON-WATER-RELATED ENVIRONMENT EFFECTS OF AGRICULTURAL ACTIVITIES

Although the farmer is probably the original ecologist, the adverse effects of agricultural activities, other than those to our water resources, are numerous and often severe. Among the major problem areas are solid waste management, air pollution, vector control, pesticides and land use.

According to the first annual report of the Council on Environmental Quality, the largest single source of solid wastes in this country is agriculture. It accounts for more than half of the total wastes produced each year. For example, in 1969, 4.3 billion tons of solid wastes were produced in the United States: of this, 2,280 million tons were produced by agriculture.

The principal agricultural and forestry wastes generated in the United States are animal manures, vineyard and orchard prunings, crop harvesting residues, animal carcasses, greenhouse wastes and pesticide containers. The composition of these wastes is indicated in Tables 1 and 2.

Although estimates vary, at a minimum, domestic animals produce over 1 billion tons of fecal wastes a year and over 400 million tons of liquid wastes. Used bedding, paunch manure from abattoirs, and dead carcasses make the total annual production of animal wastes close to 2 billion tons.

As much as 50 percent of animal wastes is generated in concentrated growing operations close to urban areas. Large-scale animal husbandry operations have developed rapidly in the last twenty years. One operation with 10,000 head of cattle on a feedlot can produce 260 tons of manure per day. An operation involving 400 milk cows produces about 14 tons of solid waste daily. A poultry enterprise with 100,000 birds produces 5 tons of waste daily. Table 3 indicates the total waste production by major animal classes. Animal manures, from concentrated livestock production systems, have been associated with various types of pollution, such as fish-kills, eutrophication of lakes, off-flavors in surface waters, excessive nitrate contamination of aquifers, odors, dusts, and the wholesale production of flies and other noxious insects.

TABLE 1 COMPOSITION OF SOLID WASTES FROM AGRICULTURAL SOURCES

Agricultural Source	Waste	Composition
Farms, ranches, greenhouses, livestock feeders, and growers	Crop residue	Cornstalks, tree prunings, pea vines, sugarcane stalks (bagasse), green drop, cull fruit, cull vegetables, rice, barley, wheat and oats stubble, rice hulls, fertilizer residue
	Forest slash	Trees, stumps, limbs, debris
	Animal manure (Paunch manure)	Ligneous and fibrous organic matter, nitrogen, phosphorus, potassium, volatile acids, proteins, fats, carbohydrates
	Poultry manure	Same as animal manure
	Animal carcasses, flesh, blood, fat particles, hair, bones, oil, grease	Ammonia, urea, amines, nitrates, inorganic salts, various organic and nitrogen-containing compounds
	Pesticides, insecticides, herbicides, fungicides, vermicide and microbicide residues and containers	Chlorinated hydrocarbons, organo-phosphorus compounds, other organic and inorganic substances, e.g., strychnine and lead arsenate

TABLE 2 SOLID WASTE GENERATION FROM MAJOR AGRICULTURAL CROPS (1966)[a]

Crop	Acres harvested (thousands)	Field waste load (tons/cap/yr)	Field waste load (mil. tons/yr)	Nature of waste
Corn, for grain	56,888	4.5	255.996	Leaves, stalks
Wheat " "	49,843	1.3	64.796	Stubble
Oats " "	17,848	1.8	32.126	"
Barley " "	10,226	1.8	18.407	"
Rye " "	1,283	1.3	1.668	"
Mixed grains	1,000	1.3	1.300	"
Rice	1,967	3.0	5.901	"
Flaxseed	2,627	0.8	2.102	Leaves, stalks
Alfalfa-clover seed	1,312	0.8	1.050	"
Sorghum, for grain	12,837	3.0	38.511	"
Cotton	9,595	2.0	19.190	"
Beans, dry	1,519	2.0	3.038	"
Peas, dry	344	2.0	.688	"
Soybeans, for beans	36,644	2.0	73.288	"
Peanuts, for nuts	1,436	3.0	4.308	"
Potatoes	1,479	3.0	4.437	Leaves, vines
Sweet potatoes	187	3.0	.561	"
Tobacco	967	0.5	.488	"
Sugar cane, for sugar	630	0.5	.315	Leaves, stalks
Sugar beets	1,161	3.0	3.483	Leaves
Vegetables	3,636	3.0	10.908	Leaves, stalks, culls
Fruits, nuts	4,699	2.0	9.398	Prunings, leaves, culls
TOTALS	218,137		551.959	
			2.760	tons per capita per year
			5,520.	lbs per capita per year
			15.1	lbs per capita per day[b]

[a]Does not include non-waste producing crops such as hay, silage, etc.

TABLE 3

SOLID WASTE GENERATION BY MAJOR FARM ANIMALS (1966)

Animal	Number on Farms (thousands)	Waste load (manure) (tons/unit/yr)	(thousand tons/yr)	
Cattle	108,862	10	1,088,620	
Hogs	47,414	8	379,312	
Sheep	21,456	3	64,368	
Horses, mules	No estimate since 1960	-------	---------	
Poultry				
Broilers	2,568,338	.0045	11,557	
Turkeys	115,507	.025	2,888	
Layers	339,921	.047	15,976	
Ducks, etc.	No estimate	-------	---------	
TOTAL			1,562,721	
			7,814	tons/cap/yr.
			15,627.2	lbs/cap/yr.
			42.8	lbs/cap/day

In the past, animal wastes were considered to be a tremendous asset and were used in augmenting the fertility of the nation's soils. Currently, it is usually cheaper for the farmer to replenish his fields with concentrated chemical fertilizer than it is to haul manure in sufficient amounts from his farm to his field. It appears, however, that the necessity to dispose of these wastes so as to protect our water resources is reversing this trend which was based on purely economic considerations.

The disposal of dead animals has become a problem. Rendering plant operators will only pick up the carcasses in certain areas and then only provided they are placed in metal containers. Dead chickens constitute a large portion of the yearly collection of carcasses.

Plant residues from crops, orchards and forests contribute to pollution in two ways: as a source of smoke and other air pollutants when burned, and as reservoirs of plant diseases and other pests. Much agricultural waste from orchards, grainfields and rangelands, especially in the Western United States, is burned as the practical means of ridding the land of wastes. Vast quantities of sugar cane trash and cereal straw and stubble are burned or allowed to decay in the field. Buring is a usual method of disposing of prunings and is also carried out as a means of disease and insect control. Forest slash, unlike sawdust and shavings from sawmill operations, is little utilized and is usually allowed to accumulate. This material is a fire hazard and may also become a serious source of organisms causing plant diseases. The current method of handling this waste is by burning.

Shredding followed by incorporation of the shredded wastes into the soil has been tried as a means of disposing of orchard wastes. Advantages of the shredding-burying system of disposal are the avoidance of the air pollution which results from burning and the return of organic matter to the soil. A disadvantage inherent in burial of the shredded material is that plant diseases and insects may be perpetuated.

Until means are found for controlling the survival of plant pathogens in the buried wastes,burning appears to be the only safe way--with respect to plants--of disposing of orchard and vineyard residues. Disinfection by chemicals would seem to be one way of circumventing the spread of the fungal diseases. Residues left in the field and orchards give rise to problems of vector control and to aesthetic considerations.

Although, in terms of weight, pesticide containers make up only a small portion of the solid wastes from agricultural activities, they are one of the major solid waste problems. Accumulations of pesticide containers occur in agricultural areas and may constitute a hazard to humans and livestock. Unfortunately, many of the containers in which pesticides are distributed are especially attractive for reuse for other purposes. The solution to this problem is principally educational and the Department of Agriculture is actively engaged in teaching farmers where and how to dispose of empty containers and unwanted pesticides.

Indirectly associated with agriculture, per se, are the wastes resulting from the food processing industry. Modern agricultural methods have resulted in a larger portion of the waste being carried to the processing plant rather than being retained at the site of production. According to the National Canners Association, the food industry annually generates 13 million tons of food wastes. Processing of 100 pounds of raw food results in an average of 36 pounds of waste material. An average 19 pounds of this 36 pounds may be recovered as animal feed or as a by-product. The remaining 17 pounds must be handled and disposed of as wet solid waste.

As previously described, burning is in many cases the current method of controlling solid wastes. In many cases, the effect on air has not been quantified. Such estimates as are available indicate that the practice should be discontinued where possible. For example, around 900,000 acres of grass are grown for lawn and pasture seed each year, with the production of about 2 tons of residue per acre. Estimates indicate that about one-third of this acreage is burned each year as a sanitation measure. Such burning releases some 50,000 tons of particulate matter into the atmosphere. Prescribed burning in forests each year produces about 32 cubic miles of smoke in the convection column, while generating 6.5 million tons of particulate matter and 68,000 tons of hydrocarbons. Particulates from burning agricultural wastes are significant. The smoke often also produces a significant aesthetic factor.

Evaluations of the relative contribution of burning agricultural wastes to photochemical air pollution have been attempted. The studies indicated that concentrations of photochemically active hydrocarbons were negligible at a mile and a half from the fire when more than 1,000 acres of wastes were burned. The emissions of hydrocarbons and oxides of nitrogen from burning of agricultural wastes were considerably less per ton of fuel consumed than those in auto exhaust. The burning of fruit tree prunings, rice straw, barley straw, and dry native range brush produced approximately 14, 9, 18 and 7 pounds, respectively, of hydrocarbons compared with 130 pounds of the same hydrocarbons in auto exhaust per ton of fuel consumed. It appears from this limited study that the burning of agricultural wastes does not add significantly to the burden of photochemical air pollutants in community air.

On the whole, agricultural burning is on the decline because of changing farming practices and new open burning air pollution control regulations. Although irrigation ditch banks are seared in spring to destroy new weeds and those which sprouted after the previous burning, burning of grain stubble and corn stalks, which is environmentally indefensible and unnecessary, is declining. Burning of fence rows is also declining. This is due in part to the fact that there are fewer fences, and these increasingly of the single strand type, which intercept fewer tumbleweeds, thus reducing the necessity for burning. Burning of prunings is also declining. It has

largely been replaced by disking as a means of disposing of grapevine prunings in modern vineyards, although burning continues to be practiced in the older vineyards in which close planting precludes disking. Burning of orchard prunings is declining under the weight of air pollution control enforcement.

Smudge fires for the protection of blossoms of fruit from low temperatures have given way to the more sophisticated and ecologically acceptable concept of "orchard heating." Diesel fuel and propane, burned in devices engineered for the purpose, produce much less pollution than crankcase oil and old tires while serving more effectively.

During the average year, 30 million tons of natural dusts enter the atmosphere. Most of this arises as soil blowing from inadequately protected fields under cultivation, deteriorated rangelands, and sand dune areas. A small amount arises from highway and industrial construction sites. Susceptibility to wind erosion is the dominant problem of 55 million acres of cropland in the United States.

Windblown soil not only robs the land of good topsoil, it also becomes a serious air pollutant. Respiratory ailments are accentuated. Eyes are afflicted and highway and air vision are impaired. Machinery is scourged by paint removal and dirt in bearings. Offices, homes and factories are completely permeated by dust. Pesticides clinging to soil particles may be carried long distances and fence rows and ditches may be partially buried by drifts of dust.

In expanding the research on the problems of soil blowing in the Great Plains, consideration must be given to various concepts for describing and delineating the influence of atmospheric wind and turbulence on soil detachment and transport; effect of wind and related atmospheric factors in soil drying and creation of soil surface conditions susceptible to high rates of detachment; modification of tillage practices and machines to provide effective and lasting crop residues and soil cloddiness conditions to resist soil detachment; the development of grasses and crops to tie down soils susceptible to blowing; design of better windbreaks and selection of better shrubs and trees as windbreaks.

Much better information is needed on techniques to curb dust production on large feedlots. These dusts are not only a nuisance to the housewife but of serious concern to those with dust allergies. It is also suspected that dust in these feedlots reduces efficiency of weight gain. Sprinkling is one technique that has been used with some success. However, further study of the problem is needed to develop alternate methods and more economical sprinkling techniques.

One of the major air pollution problems associated with agriculture is odor from animal feedlots. This problem is accentuated by poor land use practices, including the inadequacies of the buffer zones set up by agri-

cultural enterprises. On both the East and West coasts, concentrated egg production, swine production, and dairy production enterprises have been forced to cease or relocate their operations because odors and other nuisances were objected to by their metropolitan neighbors. The New York-New Jersey and the Los Angeles areas are prime examples of this problem. Within the last six years, 43 dairy operations have had to move out of Los Angeles County. In the Midwest, numerous damage suits have been brought against large feedlots because of odors, dust and flies. Use of odor masking chemicals for partial control may create secondary problems, since they may also be objectionable and there is little known of their potential pollution effects. Certainly, of all types of pollution that may arise from feedlots, the problem of odor is the one most apt to bring public pressure on the feedlot owner.

Two agri-business operations that cause considerable air pollution in this area are grain elevators and alfalfa mills. Grain dust is released into the air principally during the loading and unloading process at the grain elevators. The grain dusts, in addition to adding a considerable load of particulates to the air, appear to cause an allergic reaction among certain people. For example, it has been well documented in New Orleans that the incidence of asthmatic problems increases significantly when the population is subjected to grain dusts by a change in the wind. The solution to this air pollution problem is a closed system for loading and unloading and a bag house instead of the more commonly used cyclone.

Alfalfa mills cause problems that are very similar to those caused by grain elevators and are a major problem in many States, including Iowa, Missouri, South Dakota, Nebraska, Wyoming, and Colorado. Here again the solution lies in the incorporation of closed systems and bag houses instead of cyclones. In the 1950's use of cloth bags in the bag houses for alfalfa plants resulted in some fires. Many mills are still reluctant to install bag houses on this account, despite the fact that the fiber glass bags which are now available make the danger of fire minimal.

A great deal of work has been done on the movement and effects of pesticides in water and these points have been discussed in the first chapter. It is important to note, however, that pesticides often affect man's health or the environment without passing through water. Accidental poisoning is an everpresent possibility and can occur if old pesticide containers are unwisely reused, if aerial sprays are carried into populated areas by the wind, or if workers enter a field too soon after pesticide application, to name just three cases. Although a good deal has been done to minimize the possibility of such accidental contamination through proper registration and training, much more should be done. Institutional controls, such as Federal and State laws, need particular attention. For example, California is one of few states that prohibits aerial spraying of crops when wind velocities are above a certain level. Again, under Federal laws, pesticides can be seized only under certain circumstance. Often, Federal authorities will have little choice but to allow an untrained

person to keep what would seem to be an excessively dangerous pesticide and to use it as he sees fit.

In connection with pesticides, an issue which has attracted a great deal of attention in this area during recent months is the desirability of poisoning programs for predator control. This problem made national headlines when it was discovered that animal carcasses heavily baited with thallium sulfate may have caused the deaths of over 50 bald and golden eagles in Wyoming. The Colorado Department of Fish and Game has refused to take part in future predator control programs if they involve poison and there is a good deal of public support for this position.

Although it is often overlooked in discussions on the effects of concentrated feeding operations, the importance of animal wastes in the reproduction of insect vectors of many potential diseases is well documented. Studies in California in the past few years have indicated that one of the foremost causes for the prodigious numbers of flies today is the high density concentrations of animals in livestock-husbandry operations. Under range or pasture conditions some flies tend not to develop in the individual droppings and others tend to develop in fewer numbers. The drying out of droppings and the predation of other species on fly larvae and adults tend to contribute to the control of flies. In contrast, high density confinement production tends to create ideal conditions for domestic or filth fly production. Control of such vectors involves frequent removal of manure from animal quarters and the rapid treatment and disposal of the wastes. Thus, the problem becomes one of developing rapid and efficient methods of waste management and disposal. In this regard, it should be stressed that detention ponds and lagoons, unless properly designed, constructed and maintained, can lead to heavy production of mosquitoes and other aquatic insects which may transmit important diseases.

Noise pollution is only just beginning to attract attention, but it seems that much farm machinery may have to be modified if a noise pollution control program is initiated. The specific effects of noise on the human body have been fully investigated and documented. That noise can affect the inner ear and cause loss of the ability to hear certain frequencies--called noise deafness--was documented a century ago in connection with boilermakers. Only recently, however, have researchers found that noise can also hurt more profound parts of the body, such as the cardiovascular system. Noise increases the level of artery-clogging cholesterol in the blood and it raises blood pressure. Even moderate noises cause some blood vessels in the body to constrict and to reduce or cut off blood flow. Noise has the opposite effect on blood vessels of the brain: it makes them dilate and may be one way in which noise causes headaches.

Other effects of noise on the body include changes in secretion of acid by the stomach, changes in secretion of endocrine hormones, and changes in the functioning of the kidneys. More subtly, noise may have significant effects on personality and mental health.

The public is aware of some of these problems. In late September, a public hearing was held in Denver on the subject of agricultural noise. The results of these hearings will be incorporated into a report to Congress later this year.

One of the most difficult problem areas to assess or define in relation to agricultural activities and the environment is that of land use. In many cases, the farmer is the victim when land use controls are poor or non-existent. The urban and suburban environment frequently surrounds the farmer, increasing his taxes and, in the case of feedlots, subjecting him to nuisance suits on the basis of odor problems. In many cases, the nation is the loser. Some of our best farm land is being taken out of production. For many such problems, the only satisfactory solution may be a comprehensive land use plan and adequate regulatory controls to implement it.

What is needed, also, is a recognition of the importance of the rural-urban interface. Ways must be found to assist the planner, the developer, and the engineer to incorporate sound conservation principles in suburban development. They must learn the effects of poor location and land use on the environment. These people, who are a large part of the rural-urban interface, must devote themselves to the development of land use plans that protect both the urban and rural interests and the environment.

CHAPTER IV

INSTITUTIONAL CONSIDERATIONS IN THE CONTROL OF AGRICULTURE POLLUTION PROBLEMS

A. REGULATION OF AGRICULTURAL WASTES

Regulation of agricultural wastes in the western States is closely allied to the concept of water law within the given States. It is generally recognized that two concepts of water law exist in the United States. The doctrine of reparian rights and the doctrine of prior appropriation. The former concept is dominant in the eastern and midwestern States, while the latter is prevalent in the western States.

The doctrine of reparian rights was developed by the English Common Law and was transplanted in America along with the larger body of law in institutions which is collectively referred to as the English Common Law. This law concerned itself primarily with reparian rights and it had a rather individualistic focus. The essence of that law was that a land holder immediately adjacent to the stream or body of water was a reparian owner and had, thereby, complete and exclusive use of that water.

This law can be described as being completely individualistic in its focus. As it relates to water quality, the doctrine confirms the right of each reparian owner to have the water flow by his land in a quality reasonably suitable for his desired use. If some upstream reparian user degraded the water quality below this desirable level, his pollution was actionable and the injured reparian could sue for damages or could seek to enjoin the polluting activity under the law of nuisance.

The doctrine of prior appropriation is the actual diversion of the water of a natural stream, with the intent and purpose of applying it to a beneficial use, consumated in a reasonable time thereafter by actual use of the water by the individual or individuals. Key to this doctrine is the actual use of the water within a reasonable time after it is so diverted. The appropriation runs with the land. This doctrine exists in the States of Arizona, California, Kansas, Montana, Colorado, Texas, Wyoming, Idaho, Nebraska, Nevada, New Mexico, North Dakota, South Dakota, Oklahoma, Utah, Oregon, and Washington; States concerned with the prospects of water shortage.

The body of law which resulted concerned itself with the accumulation and shortage of large quantities of water. This concern led to the building

of reserviors and ponds throughout the United States. With this quantitative concern for water came a slight shift from the previously individualistic focus to a slightly more public one. This quantitative concern was manifest as late as 1965 as was exemplified by the creation of the National Water Commission. This Commission was created in response to a confrontation between the States of California and Arizona relative to the disposition of the waters from the Columbia River Basin. An agreement was reached between the two States that neither State would take any additional waters from the Columbia River Basin than those already existing, until Congress had received the report from the National Water Commission. It has been interesting to note that while this Commission was created to resolve a quantitative dispute, with the advent of the high profile being given to environmental concerns, the Water Commission has in the last few years demonstrated the shift from this quantitative concern (a more individualistic approach to the ownership of water) to more of a public ownership and concern for the use of water.

To summarize, the law concerning water has evolved through two stages: (1) Very individualistic (the reparian owner's right to use and disposition of water irregardless of others concerned or use thereof); (2) A Qualitative concern which began to recognize others (than the reparian owner) interests in water and has somewhat mitigated the individualistic ownership of the water. We are now in the process of establishing a third phase of law which will be very collective in nature, as opposed to individualistic, which will concern the public use and concern for water to the exclusion of the individual or State or any other institutional organization.

In general, few cases involving agricultural pollution have been initiated under the law of nuisance. However, a milestone case, Atkinson v Herington Cattle Company (200 Kansas 298, 436 P.2d 816) illustrates that agricultural pollution whose origin was a feedlot, is actionable, and the downstream owner can recover substantial damages from the agricultural polluter. It is recognized, however, that nuisance cases are generally hard to win, for a variety of reasons, and the above case is the exception rather than the rule. Because of this, agricultural pollution abatement is best controlled by State or Federal regulation rather than through civil courts.

A major problem that has been encountered in proposing and implementing any king of laws or regulations relative to the control of pollution has been the paucity of a theoretical framework within which to rationalize this public interest to the exclusion of the individualistic approach which characterized the previous two stages of the development of law .

Although the distillation of the public concern for the environment, and more specifically clean water, has achieved its highest profile at the national or Federal level, it is at the State level that permit and control

programs can be most effectively and efficiently instituted and implemented. A review of the laws of the 50 States which authorize the implementation of health departments and/or other agencies specifically designated to control water and/or air seemed to indicate that there already exists statutory authority which could be construed to be broad enough to encompass a permit program. Frequently, unused statutory authority, such as the "Be fouling Statute" in Utah, also exists. Thus, in most of our States, the laws are broad enough to allow that designated agency to institute a permit program in general and more specifically a feedlot permit program. Some legal scholars are of the opinion that even if these laws are not in themselves broad enough, it can be effectively reasoned that within police powers the administrative agency can control through regulations, which is in this instance synonymous with permit. The problem then is less the creation of laws than the creation and implementation of regulations by the designated agency to control agricultural pollution.

Partial explanation for the failure of agencies to act might be one or all of the following:

1. Until recently there has not been sufficient attention, and therefore, pressure brought to bear upon the agency for the need of control mechanisms.

2. The agency workload, which in most cases is already strained could possibly break under the need for enforcement personnel.

3. The low profile that had been given to environmental factors made the method of financing and requesting these additional funds almost impossible.

4. In some States implementation of such programs may have been retarded by political pressures. However, it is not thought this could have been a major factor in reality; it exists, rather, more as a myth.

Some States have instituted permit programs specifically to control feedlots. Some of these exist specifically as a statutory mandate and others have been created through administrative regulations. Many of the State permit programs are primarily a building permit program system which, while it is good in that it is futuristic, it does not present a method to abate existing pollution. In addition, many of the State agency permit programs appear to assume the burden of data gathering and proof. These regulations then require the State to monitor, spot and bring to the attention of the polluter the problem he is causing.

A summary of the status of feedlot control in the Rocky Mountain and

Prairie States is as follows:

1. Kansas

Kansas has one of the most effective feedlot permit programs in existence. It requires that any feedlot operator feeding more than 300 cattle, 100 hogs, or 500 sheep, must register with the health department and provide pollution control facilities, if needed, to prevent pollution either from direct discharge or runoff.

2. Colorado

Colorado has no permit program to control feedlots. However, the Water Pollution Control Commission has adopted rules for control of water pollution for livestock confinement. Commission staff, recognizing the importance of a permit program, is presently attempting to conceptualize a permit program which would include feedlot control. The Department of Agriculture has issued guidelines for control of animal manure. (This is an example of the fragmentation of authority which ultimately may prove the old addage that too many cooks spoil the soup.)

3. Montana

Montana is developing guidelines for controlling feedlot wastes and have held public hearings. They are, however, delaying action further until the effect of Federal Refuse Act Permit Program is evaluated.

4. North Dakota

North Dakota indicates a desire to adopt feedlot control, but has yet to take any formal action. At the present time, they are operating under the concept of voluntary compliance.

5. South Dakota

South Dakota is in the process of adopting a feedlot control permit program. Public hearings have been held and the information evaluated. The regulation has been promulgated and final adoption will be made, provided no serious objections come forth from the citizens of South Dakota. The regulation provides for controls over feedlot operators feeding more than 500 animal units. An animal unit is equivalent to one head of

cattle. Pollution control facilities will be provided to abate pollution either from direct discharge or runoff.

6. Utah

Utah has no specific feedlot regulation, but feedlots that discharge liquid wastes must obtain a permit under the State's general permit program.

7. Wyoming

Wyoming is in the process of developing general guidelines for control of feedlots. There is no indication formal regulations will be adopted.

8. Iowa

In 1969, the Iowa legislature amended the pollution control law to require registration of all livestock and poultry operations where potential water pollution exists. Under this amendment the Commission cannot require control facilities unless they can first prove that the registrants are in fact polluting the water or may reasonably be believed to potentially pollute. Regulations issued under this amendment, however, specifies the feedlot situations in which potential pollution exists. The regulation requires registration of feedlots which confine more than 1,000 head of cattle. If the control agency determines that the registered feedlot is or may be a source of pollution, the feedlot operator is required to obtain a permit for disposal of the waste. The conditions for a permit include provision for proper waste disposal facilities. Actually, the regulation is vague and difficult to interpret and enforce.

9. Nebraska

Nebraska regulations are promulgated under the Nebraska Water Pollution Control Act, Chapter 71, Article 30. Rules and Regulations for the registration of feedlots exist. The feedlot is required to be registered if the maximum number of animals in confinement at any one time exceeds more than 300 feeder or fat cattle, 100 or more beef cattle, 100 or more dairy cattle and per rate on down for swine, turkeys, ducks, etc. Another factor the regulation takes into consideration is location. If the geographical proximity to a water course is within 500 feet, the operator must register regardless of size. In addition to this, the operator may be requested to pay the costs of replenishing fish or other wildlife which may

be destroyed as a result of spills.

10. Oklahoma

Oklahoma has an interesting twist in the control of feedlots whereby under the Oklahoma Feedlot and Yards Act of 1969, the Oklahoma Legislature governs the operation of feedlots. Any feedlot with a capacity of 250 or more livestock at any one time during the year is required to obtain a license (@ $10 to $150). This license may be revoked for any failure to comply with the provisions of the Act or any regulations adopted thereunder. In addition to this, there may be a $100 fine per day assessed.

The interesting distinction that exists between a license and a permit is that the license is more easily revoked. That is, there are fewer procedural safeguards and therefore a licensing system is more susceptible to rigid enforcement.

All of these permit systems are geared toward providing adequate retention capacity for liquid wastes and run-off. Usually the solids are spread on land, and the liquids are often also returned to crop land. There is beginning to be some concern that these wastes not be spread on the land in too concentrated an area lest groundwater nitrate problems result. Canada requires that a feedlot have one acre of land for every head of cattle for spreading wastes. The only State which has moved in this direction is Washington. There one acre is required for every two head. Both these requirements are based on a guesstimate of how much nitrogen can be taken up by a crop. As more experience is gained with spreading very large quantities of solid and liquid animal wastes on land, it is very possible that more States will institute such controls.

There is no specific Federal legislation to regulate agricultural pollution. Federal legislation has been adopted to abate pollution of navigable waters of the United States. The Water Pollution Control Act, as amended, provides for a strong State-Federal marriage to abate pollution, recognizing that the prime responsibility for preventing and controlling water pollution lies with the State. This policy, however, does not mean that the Federal Government will not intercede in a case where a State has failed to act. The 1965 amendments interjected the Federal Government very directly into the business of pollution control on most of our nation's waterways. The 65 amendments required the States to establish water quality standards for interstate waters of the nation within their jurisdiction, but also required these standards be approved by the Federal Government. Once approved they become Federal standards, subject to enforcement under

Federal enforcement procedures. Agricultural sources degrading the water below the established standards are subject to the enforcement under the law. It is recognized that enforcement actions against nonpoint sources are difficult, but point sources, for example feedlots, are definitely subject to the law.

Regulation of feedlots under the Corps of Engineers Permit Program (Section 13, 1899 Rivers and Harbors Act and Section 21b, Water Pollution Control Act) is an actuality. Feedlot operators confining more than 1,000 animal units (equivalent of one head of cattle) and who directly discharge to a water course must obtain a permit to discharge from the Corps of Engineers. The Environmental Protection Agency and the States, under Section 21b of the Water Pollution Control Act, will certify that the water quality and abatement facilities information, provided by feedlot operators, will not violate the established water quality standards.

Although this document emphasizes regulation of feedlots, it must be recognized that other forms of pollution exists. The more common to be considered is chemical fertilizers, siltation, pesticides, and salinity. There is no specific State or Federal regulations to abate pollution from the previously mentioned other forms of agricultural pollution. In most cases, these are nonpoint sources of degradation and thus difficult to control under existing State and Federal regulations. In the event of a localized area, where the source can be traced to a given point source, present State laws, and the Water Quality Standard provisions of the Federal Act would provide regulation of these sources. The States and Federal Government, however, do have laws which indirectly can control pollution by these sources. For example, several States have banned the use of DDT. Under the Pesticide Chemicals in or on Raw Agricultural Commodities Act of 1954, pesticide residues on food products have been regulated. The Federal Insecticide, Fungicide and Rodenticide Act of 1964 makes it a criminal offense to sell any "economic poison" which has not been fully and accurately registered with the U. S. Department of Agriculture. The enforcement of this Act has subsequently been placed in the hands of the Environmental Protection Agency. Any chemical to be used on food crops must indicate the proper application and show that there is no toxic residue remaining if properly used. Obviously, proper use could prevent water pollution by these chemicals.

In conclusion, the force of law has not been brought to bear on agriculture as it has on other major sources of pollution. Perhaps this is because it is less visible or perhaps it is due to the fact that it is more difficult to control. Currently, only point sources of agricultural pollution can be subject to regulation, as illustrated by emergence

of feedlot controls. As future waste sources, other than agriculture, are abated, the undesirable effects of agricultural wastes will attract regulatory concern. Professor N. William Hines indicates public regulation will take two primary forms: (1) direct restrictions on the use of chemicals in agricultural production, and (2) regulation of land-use patterns and practices. Both are indicated in proposed legislation by the Nixon Administration.

B. INTERACTION OF OTHER FEDERAL AGENCIES WITH EPA

Federal Pollution Control is not the sole responsibility of the Environmental Protection Agency. Under Executive Order 11507, all Federal Agencies must be cognizant of their responsibilities to attain a clean environment. Considering much of the western lands are Federally owned, and agriculture is a major use of these lands, control of agriculture pollution by other Federal Agencies with EPA is a major factor. Interaction between EPA and the Bureau of Reclamation (USBR), Soil Conservation Service (SCS) and the U. S. Department of Agriculture Extension Service is important. Review of these agencies is thus indicated:

1. Bureau of Reclamation (USBR)

The Bureau has been supplying water for agriculture since shortly after the turn of the century. They build the dams, diversion structures, canals, laterals and drains to provide water to the irrigators' lands in a certain area. The project planning process begins with a local group's request for a study to their Congressman. Congress authorizes the reconnaissance study. The USBR then makes the reconnaissance study. In making the study they meet with the local group to determine what they want. Then they develop the general plan based on limited field work. Federal Agencies are asked to provide their input at this time. If the reconnaissance study shows potential feasibility, the USBR asks Congress to authorize a feasibility study. During the feasibility study, the project plan is developed in considerable detail. Detailed land classification studies are made and the location and size of structures determined. Federal Agencies provide input to the study at various stages and then evaluate the plan from their standpoint. The authority for these inputs and evaluations come from various legislation, e. g., for the Fish and Wildlife Service from the Fish and Wildlife Coordination Act and for EPA from Section 3(b) of the Federal Water Pollution Control Act (FWPCA) and from Section 8 of Executive Order 11507. The Federal Agencies' reports are sent to Congress together with the USBR's feasibility with a request for Project Construction Authorization and Appropriation. If the project

is authorized and funds appropriated for development of detailed plans, the USBR proceeds with a definite plan report. Before construction starts, the local group must be organized legally so they can sign a contract with the USBR. The contracts are usually for a 50-year period in which the group agrees to repay the project cost on an annual basis.

Before the first water is delivered to the farms, the USBR often holds workshops on irrigation practices with the local group. This is, perhaps, the time when the USBR has the most contact with individual farmers. Water is delivered to the highest point on the farm and the farmer develops his own internal system to get water to the various use points on the farm. The EPA could impact farm practices by working with the USBR on the content of these workshops.

2. Soil Conservation Service (SCS)

The SCS develops multiple-purpose watershed projects under provisions of Public Law 566. Project purpose may include flood prevention; agricultural water management; municipal and industrial water supply; recreation, and fish and wildlife development. The following steps are involved in the project development and operation:

(1) Local group prepares application and sends to designated State agency.

(2) SCS and other Federal and State agencies examine project.

(3) If State approves application, it goes to SCS (State office then to Washington).

(4) SCS authorizes planning and notifies interested agencies.

(5) Detailed field studies are made by SCS and other agencies (Forest Service, Fish and Wildlife Service etc.).

(6) The local organization prepares workplan with the SCS assistance. Informal field review in which any agency can participate is held. EPA can impact elements of workplan at that time if they choose.

(7) SCS State Conservationist approves the workplan. If cost exceeds $250,000 or single structure holds more than 2,500 acre-feet of water, other agencies review the plan (EPA reviews under 3(b) of FWPCA and Section 8 of E. O. 11507), and the plan is sent to Congress for approval by Committees.

(8) Funds are appropriated by Congress.

(9) Cost Sharing is determined.

(10) Land rights are obtained.

(11) Loans and advances are made to local organization.

(12) Local organization does soil and water conservation treatment before structures built. SCS provides technical assistance. EPA could work with SCS on this phase.

(13) Engineering work is done by local organization or SCS.

(14) Contract between SCS and local organization is signed.

(15) Local organization solicits bids and awards contracts.

(16) Local organization is responsible for operation and maintenance (O&M), but must sign an O&M agreement with SCS before construction. EPA could find a way to review and evaluate this agreement. Currently, there is no way to do this, except perhaps by mutual consent with SCS.

Throughout the nation there are many Soil Conservation Districts established by State Law. Each District is managed by a board of supervisors who develop long-range conservation programs. Participation of landowners is voluntary. Supervisors may request assistance from the SCS and other public and private agencies. The SCS maintains field offices in most counties to assist local Districts. These field people are in constant contact with the local farmers. EPA would work with the SCS to get our ideas to farmers.

3. United States Department of Agriculture Extension Service

The Extension Service is the educational arm of the Department of Agriculture. The key positions, as far as pollution abatement

is concerned, are the county and area agents. These individuals provide technical assistance to counties and areas. They work with the individual farmer. Through these agents, proper pollution control (to prevent chemical pollution, siltation and pesticide control) can be disseminated directly to farmers. The county agent can be an important person in regulation of agricultural pollution and should be utilized.